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GROWTH AND DEVELOPMENT OF COTTON PLANTS AT GREENVILLE, TEX.

H. C. McNAMARA
Assistant Agronomist

J. W. HUBBARD
Assistant Scientific Aid, and

R. E. BECKETT
Principal Scientific Aid, Office of Cotton, Rubber, and Other Tropical Plants, Bureau of Plant Industry

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INTRODUCTION

More definite information is needed on the habits of growth and fruit development of the cotton plant under the various climatic and seasonal conditions of the different cotton-growing regions of the United States. Methods of controlling the boll weevil and improved cultural methods can be more intelligently studied and applied, and possibly new methods evolved, as a more intimate understanding of the cotton plant is obtained.

The data here reported relate to the growth and behavior of the cotton plant under various cultural methods, as affected by the environmental conditions at Greenville, Tex. These studies were made during the years 1923, 1924, and 1925, with the object of associating the results with those reported from various other locations.

Although data of this nature have been published,[1] it appeared desirable to continue the studies under the environmental conditions

[1] HARLAND, S. C. MANURIAL EXPERIMENTS WITH SEA ISLAND COTTON IN ST. VINCENT, WITH SOME NOTES ON FACTORS AFFECTING THE YIELDS. West Indian Bul. 16: 169-202, illus. 1917.
MARTIN, R. D., BALLARD, W. W., and SIMPSON, D. M. GROWTH OF FRUITING PARTS IN COTTON PLANTS. Jour. Agr. Research 25: 195-208, illus. 1923.

of northeastern Texas, which is an important region of production. Several new features were also investigated, with results that are not in accord with some of the inferences drawn from the previous investigations. Nevertheless, the data of development at Greenville do coincide remarkably with corresponding data from other localities, even where the soil and seasonal conditions were widely different. Most of the new data were obtained from experiments with different dates of planting, which made it possible to record and compare the behavior of plants of the same size and stage of development during different parts of the growing season, as well as to make comparisons of plants in various stages of development at the same time.

SOIL AND SEASONAL CONDITIONS

Greenville is situated in Hunt County, northeastern Texas, about 52 miles northeast of Dallas and 60 miles southeast of Denison. It is near the line of division between the well-known black-land prairie belt of Texas and the interior coastal plains of the eastern part of the State. The soil of the United States Cotton-Breeding Field Station, where the work herein reported was done, is a very heavy fertile "black-land" clay, highly retentive of moisture, which enables the cotton plants to remain in a growing condition over long periods of dry weather. The black-land soil is technically described as Houston clay.

The 10-year average annual precipitation is 39.09 inches. The growing season is approximately 235 days, with the first killing frost, over a 10-year average, on November 11 and the last in the spring on March 21. Occasional wide departures from these means may be expected, the greatest climatic variation being with respect to rainfall. Although the average annual precipitation at Greenville is rather high, the summers are usually dry and hot, and the cotton plants often suffer for moisture.

METHODS OF PROCEDURE

This work is devoted principally to the normal rate and sequence of production and the growth and development of the fruiting parts of cotton. Special attention has been given to the effect of different dates of planting and different spacings upon these characters.

The normal sequence and rate of flower production was studied on 35 plants selected to represent equal development at the beginning of the flowering period. Daily observations were made on these plants throughout the flowering season and the position and date of appearance of each flower recorded. These records show the intervals between the appearance of successive flowers on fruiting branches and between the first flowers on successive fruiting branches.

Studies to determine the effect of date of planting upon the growth and fruit development of cotton plants were conducted in the date-of-planting experiments of 1923, 1924, and 1925. The Lone Star variety was used for these experiments, and the different plantings were made as follows: Nine weekly plantings in 1923, made April

2, 9, 16, 23, May 3, 7, 14, 21, and 28; four plantings in 1924, made April 10, May 1, 14, and June 2; and four plantings in 1925, made March 28, April 18, May 20, and June 8. In addition to the four field plantings made in the regular date-of-planting experiment in 1924, six smaller plantings were made after June 2, and extend to August 15. Data from these plantings are included with the 1924 date-of-planting experiment.

These experiments were planted in 6-row blocks 312 feet long and duplicated, and in 1924 and 1925 the blocks were divided into two equal sections at thinning time, one section being thinned to one plant every 12 inches and the other left unthinned.

In 1924, 16 plants were selected for study in each planting, 8 in the thinned sections and 8 in the unthinned sections. These plants, numbering 64 in all, were carefully selected to represent the average plant from each date of planting. Beginning with the appearance of the first square, daily observations were made of these plants, and the date of appearance and position on the plant of all squares, flowers, and open bolls were recorded. Similar data were taken in 1923, except that only three plants were selected from each planting. In 1925 more general observations were made on a larger population of plants.

Comparisons of the growth and development of seven varieties of cotton were made in 1923 and 1924, employing the same methods as those used on the different plantings. The varieties studied were Kasch, Mebane Latest Improved, Rowden, Truitt, Lone Star, Acala, and Kekchi, all of which, with the exception of Kekchi, are widely grown throughout the Cotton Belt of Texas.

SEQUENCE AND RATE OF FLOWERING

During the season of 1924 a series of observations was made to determine the normal sequence and rate of flower production of Lone Star cotton under ordinary field conditions. These observations were begun July 8 by selecting 35 plants which produced their first flower on that date. Daily observations were made of these plants throughout the flowering season, and the exact position and date of appearance of each flower was recorded on a diagram.

Of these 35 plants, 25 produced their first flowers in the same relative position, at the first node of the first fruiting branch, which grew from the seventh node of the main stalk. Hence it appeared that these 25 plants were more strictly comparable in their development at the beginning of the test, and the data here given are from these 25 plants exclusively. The records of these 25 plants are given in Table 1, which shows the position and date of appearance of all of the flowers produced on these plants. The flowering period extended from July 8 to August 3, and the dates shown from 8 to 31 are for July and from 1 to 3 are for August. The fruiting branches are designated by the node of the main stalk from which they grew, and the nodes of the branches are numbered, beginning at the base. The date of each flower is placed under the node of the branch at which it occurred.

TABLE 1.—*Positions and dates of appearance of flowers of 25 cotton plants which produced their first flower on the same date and in the same position on the plant*

[The dates of appearance of flowers from 8 to 31 are in July; from 1 to 3 in August]

Plant	Positions of branches on main stalk (nodes 7 to 17) and of fruiting-branch nodes (1 to 4) and dates of flowering																																							
	Node 7				Node 8				Node 9				Node 10				Node 11				Node 12				Node 13				Node 14		Node 15		Node 16	Node 17									
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3		1	2	3		1	2	3		1	2	1	2	1	1							
No. 1	8	15	--	--	11	16	24	--	12	18	--	--	14	21	--	--	16	23	--		19	26	--		22	29	--		24	---	28	---	------	------							
No. 2	8	14	21	--	11	16	22	--	12	18	26	--	15	21	28	--	17	24	30		20	27	--		22	28	--		25	---	28	---	31	------							
No. 3	8	16	--	--	10	16	21	28	12	17	25	--	13	19	25	--	16	--	--		18	25	--		21	26	--		25	30	27	---	30	------							
No. 4	8	--	--	--	10	16	22	--	10	16	22	29	14	19	25	--	16	22	--		18	22	--		19	26	--		23	---	25	---	27	31							
No. 5	8	--	--	--	10	15	20	--	12	17	23	29	14	19	25	--	16	22	28		18	24	30		20	27	--		23	---	25	---	28	1							
No. 6	8	15	21	--	11	16	22	--	13	18	24	--	15	21	--	--	17	24	--		18	25	31		21	27	--		24	30	26	1	29	1							
No. 7	8	16	--	--	10	17	21	--	11	18	25	--	14	19	26	31	16	22	28		19	25	30		21	27	--		24	30	27	1	30	1							
No. 8	8	--	--	--	10	17	--	--	12	18	--	--	15	20	27	--	17	23	29		19	26	1		21	28	--		25	31	27	---	30	2							
No. 9	8	16	--	--	9	16	23	--	11	17	--	--	14	22	27	--	16	23	28		19	26	--		20	27	--		24	---	26	---	------	------							
No. 10	8	15	22	--	11	16	24	--	12	17	26	1	15	20	27	--	17	23	29		19	27	1		21	28	3		25	1	28	3	31	3							
No. 11	8	16	24	--	11	16	23	28	12	17	24	29	15	22	26	--	17	24	29		19	26	--		22	28	1		25	31	---	2	30	2							
No. 12	8	15	--	--	9	15	21	28	12	17	25	--	13	18	25	--	--	22	28		19	26	--		21	--	--		25	---	26	---	------	------							
No. 13	8	16	20	--	10	16	22	--	12	17	24	--	14	20	27	--	17	23	29		19	26	--		22	28	--		24	31	27	---	30	------							
No. 14	8	15	23	--	11	16	22	--	12	18	25	--	15	21	--	--	17	24	--		20	27	--		22	29	--		25	---	28	---	------	------							
No. 15	8	14	21	27	12	16	22	--	13	17	24	--	15	20	26	--	18	24	30		19	25	1		23	29	--		25	31	27	---	31	------							
No. 16	8	15	--	--	9	16	--	--	--	--	25	31	15	20	28	--	17	23	--		20	26	--		21	27	--		21	31	27	---	30	------							
No. 17	8	14	--	--	11	18	25	--	12	17	24	--	14	20	27	--	17	25	--		19	26	--		22	28	--		24	---	27	---	29	------							
No. 18	8	14	21	--	10	16	23	--	13	18	24	--	14	20	27	--	17	23	--		19	25	--		21	28	--		24	---	27	---	------	------							
No. 19	8	--	--	--	10	16	22	--	12	17	25	--	14	19	26	--	16	22	--		19	--	--		21	--	--		24	---	27	---	------	------							
No. 20	8	15	21	--	10	16	22	--	12	17	23	--	14	19	26	--	16	22	--		19	26	--		21	--	--		24	---	26	---	30	------							
No. 21	8	14	--	--	10	16	23	--	12	17	25	--	14	19	26	--	16	22	--		18	25	--		20	27	--		24	29	26	---	------	------							
No. 22	8	14	20	--	10	16	23	--	12	17	25	--	14	19	26	--	16	22	28		17	24	--		20	27	--		22	29	26	1	28	1							
No. 23	8	14	--	29	10	15	22	--	12	16	22	--	14	20	--	--	16	22	--		18	24	--		21	28	--		23	31	26	---	------	------							
No. 24	8	--	--	--	10	16	22	--	12	17	21	--	15	19	--	--	16	23	--		18	25	--		21	--	--		24	---	27	---	------	------							
No. 25	8	14	21	--	9	15	21	--	12	16	--	--	14	19	--	--	16	22	--		18	--	--		20	27	--		23	---	26	---	------	------							

As will be seen from Table 1, the flowering of these plants was remarkably uniform throughout, with only slight variation of intervals, although no two plants were found that produced their flowers on the same days at all of the corresponding positions. The nearest approach to a complete agreement was on plants 21 and 22, where the flowers at all positions opened on corresponding dates, except two flowers on the branch of the twelfth node and one on the branch of the fourteenth node.

INTERVAL BETWEEN SUCCESSIVE FLOWERS ON FRUITING BRANCHES

The interval between successive flowers on the same fruiting branch ranged from 4 to 10 days. In 279 cases recorded the 6-day interval appeared 111 times, the 7-day interval 86 times, and the 5-day interval 49 times. The three intervals together—5, 6, and 7 days—accounted for 246 cases, leaving only 33 stragglers outside. These figures indicate that successive flowers on any fruiting branch may be expected to appear at from 5 to 7 day intervals. A few flowers appeared at 4-day and 8-day intervals, and 9-day and 10-day intervals were recorded only once each. In no case did successive flowers on any fruiting branch in the test appear at an interval less than 4 days.

The interval between successive flowers on fruiting branches and the number of cases in which they occurred are shown in Table 2.

TABLE 2.—*Interval between flowers on fruiting branches and the number of cases in which they occurred in a population of 25 cotton plants*

Interval between flowers on same fruiting branch	Positions of branches on main stalk (nodes 7 to 15) and of fruiting-branch nodes (1 to 4)																				Total
	Node 7			Node 8			Node 9			Node 10			Node 11		Node 12		Node 13		Node 14	Node 15	
	1 and 2	2 and 3	3 and 4	1 and 2	2 and 3	3 and 4	1 and 2	2 and 3	3 and 4	1 and 2	2 and 3	3 and 4	1 and 2	2 and 3	1 and 2	2 and 3	1 and 2	2 and 3	1 and 2	1 and 2	
4 days	---	1	---	1	1	---	3	1	---	1	1	---	---	---	1	---	---	1	---	---	11
5 days	---	---	---	8	2	1	14	0	1	13	1	1	---	2	---	2	1	---	2	1	49
6 days	8	3	1	11	11	---	6	6	3	8	4	---	15	9	6	3	8	1	5	3	111
7 days	7	5	---	5	7	2	1	6	1	2	12	---	7	---	15	1	12	---	3	------	86
8 days	5	2	---	---	2	---	---	6	---	1	1	---	1	---	1	---	---	---	1	------	20
9 days	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---	------	------	1
10 days	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	------	1

INTERVAL BETWEEN FIRST FLOWERS OF SUCCESSIVE BRANCHES

The number of days between the flowers at the first nodes of successive fruiting branches are presented in Table 3. The intervals ranged from 0, or simultaneous flowering, to 6 days, and the figures in the columns represent the number of occurrences of intervals corresponding to the positions indicated by the nodes of the main stalk where the branches occurred, as in Table 1.

In the 217 cases recorded, the 2-day interval occurred 99 times, the 3-day interval 75 times, the 1-day interval 23 times, and the 4-day interval 17 times. One 6-day interval was recorded, and there were two cases where the first flowers of two successive branches opened on the same day.

It is notable that 80 of the 99 two-day intervals recorded were between flowers of the first seven fruiting branches, whereas 35 of the 75 three-day intervals and 14 of the 17 four-day intervals were recorded on branches above the seventh. The lengthening of these intervals near the top of the plants may be attributed to different causes, but in conjunction with other similar data recorded in this circular it appears that the chief cause would be the slower rate of plant growth late in the season.

TABLE 3.—*Intervals between flowers on successive fruiting branches and frequency distribution in a population of 25 cotton plants*

Interval between flowers on successive fruiting branches	Position of branches on main stalk and frequency distribution										Total
	Nodes 7 and 8	Nodes 8 and 9	Nodes 9 and 10	Nodes 10 and 11	Nodes 11 and 12	Nodes 12 and 13	Nodes 13 and 14	Nodes 14 and 15	Nodes 15 and 16	Nodes 16 and 17	
0 day	------	1	------	------	------	------	1	------	------	------	2
1 day	4	8	3	1	3	3	------	1	------	------	23
2 days	13	12	12	18	13	12	6	9	3	1	99
3 days	7	3	8	5	8	9	11	11	9	4	75
4 days	1	------	1	------	------	1	7	2	2	3	17
5 days	------	------	------	------	------	------	------	------	------	------	0
6 days	------	------	------	------	------	------	------	1	------	------	1

These observations show that the mean number of days between successive flowers on fruiting branches was 6.2, whereas the mean interval between the first flowers of successive fruiting branches was 2.4 days. These intervals agree very closely with those reported by Martin, Ballard, and Simpson[2] under conditions more favorable for plant growth than obtained in this test.

The interval between the first flowers of successive fruiting branches being much less than the interval between the successive flowers on the fruiting branches, it follows that cotton plants are able to produce flowers more rapidly in an ascending series along the axis of the plant than in a horizontal series along the fruiting branches. This relation is especially important in the early period of flowering, or under shorter season conditions, and partially accounts for earlier maturity of closely spaced cotton as compared with wider spacings.

GROWTH AND DEVELOPMENT AS AFFECTED BY DATE OF PLANTING

The experiments with different dates of planting in 1923, 1924, and 1925 afforded unusual opportunities for the study of plant development. These plantings were begun each year as soon as the weather conditions would permit, and they extended throughout the practical planting period. In addition to the regular field plantings, six small plantings were made in 1924, extending the range of planting from June 2 to August 15, for the purpose of studying the seedling growth only. From a study of the plantings made at different dates in the three years, differences of behavior have been determined. The effects of different dates of planting upon the rate of growth and development were studied through the different stages from planting to maturity, with plantings of various stages of development available for comparison at any time.

BEHAVIOR OF SEEDLINGS AT DIFFERENT DATES

It was observed in each season of these experiments that the early planted cotton was usually slow in germinating, came up to a poor stand, and many of the plants were injured by sore shin, tomosis, black arm, and plant lice. These disorders and pests killed many of the seedlings and allowed the others to grow only very slowly. The later plantings encountered more favorable weather conditions, germinated rapidly, and were little affected by disease and aphids. Thus the later plantings made rapid growth while the early plantings were struggling to overcome their stunted and diseased condition.

In comparing the periods of seedling development in the different plantings, the appearance of the first floral bud or "square" was considered as marking the end of the seedling stage. The time required to pass through the seedling stage, from planting to appearance of the first square, was greatly reduced in the later plantings and is the most contrasting difference noted in these experiments. In 1923 the time required from planting to appearance of the first square shortened gradually from 58 days for the April 2 planting to 31 days for the May 28 planting, with the exception of the May 3 and the May 7 plantings, which were planted soon after a cool rain and were a little slow in germinating.

[2] MARTIN, R. D., BALLARD, W. W., and SIMPSON, D. M. GROWTH OF FRUITING PARTS IN COTTON PLANTS. Jour. Agr. Research 25: 196–198. 1923.

In 1924 the interval between planting and appearance of the first square was practically the same as in the preceding year for plantings made on corresponding dates, the interval gradually shortening with each successive planting until that of June 27. The April 10 planting required 53 days in the seedling stage, as compared with 20 days for the June 12 planting. All plantings made after June 12 required practically the same time in the seedling stage, the shortest periods being 19 days for plantings made July 24 and August 15. The dates of appearance of the first squares and the number of days required from planting to appearance of first squares for each date of planting in 1923 and 1924 are shown in Table 4.

TABLE 4.—*Date of appearance of first square and number of days from planting to the appearance of such square for each date of planting of cotton in 1923 and 1924*

Date of planting, 1923	Appearance of first square		Date of planting, 1924	Appearance of first square	
	Date	Time from planting (days)		Date	Time from planting (days)
Apr. 2	May 30	58	Apr. 10	June 2	53
Apr. 9	do	51	May 1	June 14	44
Apr. 16	May 31	45	May 14	June 18	35
Apr. 23	do	38	June 2	June 28	26
May 3	June 12	40	June 12	July 2	20
May 7	June 16	39	June 27	July 20	23
May 14	do	33	July 9	July 30	21
May 21	June 22	32	July 24	Aug. 12	19
May 28	June 28	31	July 29	Aug. 18	20
			Aug. 15	Sept. 3	19

In 1925 the plantings of each date were thinned when the seedlings had reached the same stage of development as closely as could be judged from the size of the plants and the number of leaves, so that the rate of seedling development is shown by the interval between the date of planting and the date of thinning. The data recorded in this way also show the more rapid growth of the later plantings. Thinning was done when the seedlings were about 6 or 7 inches high and bearing an average of 6 or 7 true leaves. Most of the plants showed small squares at this stage of development. The March 28 planting required 66 days to reach this stage of development; the April 18 planting required 62 days; the May 20 planting required 40 days; and the June 18 planting required only 29 days, or less than half the time of the March 28 planting. These data are presented in Table 5.

TABLE 5.—*Development of cotton plants at thinning time and number of days from planting to thinning in plantings on different dates in 1925*

Date planted	Date thinned	Height (inches)	Number of true leaves	Time from planting to thinning (days)
Mar. 28	June 2	6	6 to 7	66
Apr. 18	June 19	7	6 to 7	62
May 20	June 29	6 to 7	6	40
June 8	July 7	6 to 7	6 to 7	29

SEEDLING GROWTH OF VARIETIES AT DIFFERENT DATES

A series of plantings was made in 1925 covering a wide range of dates and including three varieties of cotton—Lone Star, Acala, and Kekchi. One hundred seeds of each variety were planted at weekly intervals for six successive weeks, from March 16 to April 20. After the latter date four more plantings were made at 2-week intervals, with June 15 as the last planting date. The dates of the 10 plantings were as follows: March 16, 23, 30, April 6, 13, 20, May 4, 18, June 1, and 15.

The primary object of this experiment was to compare seedlings of different varieties under a wide range of seasonal conditions with regard to earliness of fruiting. No records were made after the appearance of the first flower, as the Acala and Kekchi plants were destroyed when the first flowers appeared, to prevent crossing with pure stocks of Lone Star which were being developed on the station.

The number of days required from planting to appearance of the first square are recorded for each seedling in each of the plantings in Table 6. This table shows in 2-day periods the number of seedlings reaching the fruiting stage for each variety in each planting, and the mean number of days from planting to appearance of first square.

TABLE 6—*Periods of seedling development as shown by the number of days between planting and the appearance of first square for three varieties of cotton planted on several different dates in 1925*

Date of planting	Variety	Number of cases in each planting recorded at 2-day intervals																													Mean
		24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	
Mar. 16	Kekchi																		2	1	1	2	4	4	4	0	2	1	1	2	68.50
	Acala																	1	0	1	1	1	5	1	1	2	0	0	1	1	67.47
	Lone Star																	1	1	0	4	4	2	4	2	0	0	1	4	1	67.92
Mar. 23	Kekchi															2	3	2	1	6	1	3	1	1	3	2	1				62.00
	Acala															1	5	3	2	3	0	0	0	0	3	1					59.33
	Lone Star															2	0	2	3	4	2	3	2	3	1						61.45
Mar. 30	Kekchi													2	3	9	7	2	2	0	1	4									54.60
	Acala										2	5	2	2	3	3	3	1	1												48.82
	Lone Star											1	2	3	7	8	4	4	0	1	0	2									52.31
Apr. 6	Kekchi										2	1	6	4	2	2	0	0	4												49.14
	Acala									2	4	7	5	4	0	0	0	3	1												46.31
	Lone Star									1	9	4	10	7	2	0	0	4	4	1											47.76
Apr. 13	Kekchi									2	3	0	1	7	7	10	1	1													49.00
	Acala								1	3	2	3	2	6	13	2	1														47.33
	Lone Star									7	5	5	2	11	11	2	0	3													46.78
Apr. 20	Kekchi									3	5	12	4	2																	45.77
	Acala									1	5	7	1																		45.14
	Lone Star										4	9	10	4																	47.03
May 4	Kekchi				1	15	6	2	1	1	1																				33.55
	Acala				2	6	2	0	1																						32.55
	Lone Star				4	11	4	8	1	0	1																				33.66
May 18	Kekchi	1	6	23	5	4	3	4																							29.30
	Acala	3	4	8	5	14	3	2																							30.05
	Lone Star	1	16	8	6	4	2	3																							28.70
June 1	Kekchi		3	5	4	3	2	1	1	1	2																				31.82
	Acala		2	0	3	2	1	3	1	1																					32.77
	Lone Star		3	6	3	8	5	4	0	1	2																				32.19
June 15	Kekchi	7	20	2																											25.66
	Acala	2	13	6	2																										26.69
	Lone Star	3	22	9																											26.35

It is significant that the number of days from planting to appearance of the first square was practically the same for all varieties, and the duration of the seedling stage was reduced in the later plantings on all varieties alike. As with the other experiments, the development of the seedlings was more uniform as well as more rapid in the later plantings, as shown by more of the plants reaching the stage of square production at the same time.

INTERVAL BETWEEN APPEARANCE OF SUCCESSIVE FRUITING BRANCHES

The intervals between the appearance of successive fruiting branches were determined by carefully examining each plant daily and recording the appearance of each new fruiting branch as soon as the square became clearly visible to the naked eye, or about 1 millimeter in width. The number of days between the appearance of squares at successive nodes of the main stalk were recorded as the interval between the appearance of fruiting branches.

In 1923 the mean interval between the appearance of successive fruiting branches ranged from 2.28 ± 0.146 to 2.93 ± 0.173 days, with no definite variation between different dates of planting. In 1924 there was a slight tendency for the interval to lengthen on the later plantings, but this was confined to the plants in the 12-inch spacing. The appearance of the fruiting branches on the unthinned rows was very irregular, and the mean interval between appearance of successive fruiting branches was decidedly longer than in the 12-inch spacing.

Table 7 shows the number of fruiting branches occurring at intervals of 1 to 11 days for thinned and unthinned cotton planted on four different dates in 1924.

TABLE 7.—*Frequency distributions of intervals between the appearance of successive fruiting branches in thinned and unthinned cotton planted on four different dates in 1924*

Date of planting	Interval (in days) and frequency distribution											
	1	2	3	4	5	6	7	8	9	10	11	Mean
April 10:												
Thinned	9	31	31	13	3							2.65
Unthinned	5	22	33	8	6	2	2	2	0	1		3.23
May 1:												
Thinned	12	32	31	18	4	1	1	0	0	1		2.84
Unthinned	14	19	16	15	11	4	4	0	1	2		3.44
May 14:												
Thinned	14	35	20	15	4	3	0	1	1			2.78
Unthinned	16	30	13	6	4	2	5	1	0	1	1	2.97
June 2:												
Thinned	11	13	23	19	5	4	2	1				3.24
Unthinned	4	20	13	6	5	2	1	1	2			3.27

INTERVAL BETWEEN APPEARANCE OF SUCCESSIVE SQUARES ON FRUITING BRANCHES

The interval between the appearance of successive squares on fruiting branches is recorded as the time between the visible appearance of a square until the next succeeding square upon the same branch appears. This interval was irregular in all of the plantings, with many stragglers appearing at extremely long intervals. The majority of the squares, however, were produced within

an expected normal range, and most of the extreme long intervals occurred between squares on the extremities of the plants, after the vegetative growth had been checked.

In comparing the records from the thinned and unthinned sections, the mean interval between the appearance of successive squares on the fruiting branches was from one to two days longer for the unthinned rows than for the 12-inch spacing. Since the fruiting of closely spaced plants is restricted and most of the crop is produced on the first few nodes of short fruiting branches, a slower development of the buds at the other nodes may be expected, especially where the plants are crowded.

The numbers of successive squares that appeared on fruiting branches for each interval for the plants in the thinned and unthinned sections of four plantings in 1924 are given in Table 8.

TABLE 8.—*Frequency distribution of intervals between the appearance of successive squares on fruiting branches in thinned and unthinned cotton planted on four different dates in 1924*

Date of planting	Interval (in days) and frequency distribution																							Mean
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
April 10:																									
Thinned	1	1	11	25	29	26	30	24	10	8	5	0	0	1	0	0	0	1	1	--	--	--	--	--	7.44
Unthinned	--	3	5	18	13	26	12	19	13	8	5	2	2	0	3	0	2	0	0	0	1	0	1	1	8.45
May 1:																									
Thinned	--	--	4	21	23	30	25	33	19	5	2	2	1	2	0	0	0	2	--	--	--	--	--	--	7.94
Unthinned	--	--	1	7	9	18	3	14	14	13	4	4	11	1	3	2	1	1	0	0	0	0	1	--	9.94
May 14:																									
Thinned	--	1	10	20	27	30	24	30	15	5	2	1	3	2	1	0	1	0	1	--	--	--	--	--	7.77
Unthinned	--	1	1	6	8	13	8	8	8	6	8	5	6	1	0	1	1	0	0	1	--	--	--	--	9.44
June 2:																									
Thinned	--	1	1	13	23	24	18	21	17	7	3	1	2	--	--	--	--	--	--	--	--	--	--	--	7.90
Unthinned	--	--	--	--	2	4	12	14	3	4	2	1	3	0	1	0	1	--	--	--	--	--	--	--	9.55

SQUARE PRODUCTION AS AFFECTED BY PLANT GROWTH

The rate of square production appears to be directly associated with the growing conditions of the plant, as the intervals between the appearance of squares have been found to lengthen during periods of unfavorable weather conditions when vegetative growth was retarded. Such conditions were apparent in the first four plantings made in 1923, where the plants were checked in growth early in the season by cool weather and were severely affected by tomosis, black arm, and aphids. On these plantings, the intervals between appearance of squares were long and irregular during the adverse weather conditions early in the spring, but became normal later in the season when conditions were more favorable. Other plantings made later in the season which were not subjected to the adverse weather early in the spring produced squares at normal intervals from the beginning. As each planting became burdened with its crop of bolls and growth was retarded, the interval between the appearance of squares lengthened, especially between squares on fruiting branches.

Table 9 shows the average interval between the appearance of the first and second squares of each fruiting branch for nine dates of planting in 1923. From these data it appears that longer intervals may occur at any time during adverse conditions which retard vegetative growth. Such conditions are usually apparent early in the

spring or during the late season when vegetative growth is gradually checked by cool unfavorable weather and the plants are burdened with a crop of immature bolls.

TABLE 9.—*Intervals between the appearance of the first and second squares on each fruiting branch from plantings in 1923*

Date of planting	Fruiting branch number and interval (days)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Apr. 2	14.3	11.6	10.6	8.3	4.3	3.3	4.3	4.3	5.6	7.3	8.3	9.6	21	-----
Apr. 9	12.0	8.0	8.0	7.6	6.0	5.3	4.3	3.3	5.3	4.5	5.0	7.5	11.5	10.5
Apr. 16	13.6	11.3	9.6	6.3	3.6	3.6	4.0	4.0	4.0	7.0	8.0	8.0	10.0	-----
Apr. 23	13.6	10.3	7.0	5.0	5.3	5.0	6.3	6.0	6.6	5.3	10.0	22.0	------	-----
May 3	5.0	3.3	5.0	5.3	5.6	6.6	7.0	6.0	4.6	11.3	32.0	------	------	-----
May 7	7.3	5.3	5.3	6.3	6.0	7.6	6.6	10.0	8.5	13.0	27.0	------	------	-----
May 14	5.3	6.0	4.6	6.3	7.0	8.6	6.0	8.0	11.6	10.5	------	------	------	-----
May 21	7.6	7.3	7.6	6.6	6.6	6.0	6.0	7.0	11.0	16.5	------	------	------	-----
May 28	7.0	6.6	6.3	6.0	5.6	6.0	5.0	6.6	8.3	9.3	13.0	------	------	-----

Martin and others reporting on Pima Egyptian cotton at Sacaton, Ariz., in 1921 state that increasing intervals between successive squares on fruiting branches are correlated with the advance of season.[3] Since plantings of different ages have shown differences in intervals between squares produced in the same part of the growing season, it appears that other factors were involved in the behavior of the Lone Star variety at Greenville, Tex. In comparing early-planted and late-planted cotton it was found that at the time when the early-planted cotton had produced a crop of bolls and had begun to slow down on growth and square production the planting made eight weeks later was producing squares at normal time intervals. Thus it appears that the interval between the appearance of successive squares on fruiting branches or the production of squares in general is more closely associated with the vegetative vigor of the plants as affected by environmental conditions than with the advance in season.

PERIOD OF SQUARE DEVELOPMENT

The number of days from the appearance of a square until it flowers, which has been termed the "square period," showed a decided tendency to shorten on the late plantings. This, however, is not believed to be directly related to the advance of the season, but more likely is associated with the more vigorous and rapid growth that was apparent in the late season plantings.

In comparing the different spacings, the square period was found to be shorter on the plants in the 12-inch spacing than on those in the unthinned rows. This was especially pronounced where the plants were closely spaced in the unthinned sections, as in the June 2 planting. In 1924 the mean square period of the plants in the thinned sections was shorter than for the plants in the unthinned sections in each date of planting, the differences being 0.93 of a day for the April 10 planting, 1.09 days for the May 1 planting, 0.30 of a day for the May 14 planting, and 1.10 days for the June 2 planting.

[3] MARTIN, R. D., BALLARD, W. W., and SIMPSON, D. M. GROWTH OF FRUITING PARTS IN COTTON PLANTS. Jour. Agr. Research 25: 199. 1923.

The square periods on plants in the thinned and unthinned sections for each date of planting in 1924 are shown in Table 10.

TABLE 10.—*Frequency distribution of the period from the appearance of square until flowering date for thinned and unthinned cotton in separate plantings in 1924*

Date of planting	Interval (in days) and frequency distribution														Mean
	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
Apr. 10:															
Thinned	----	1	----	4	8	23	36	53	37	25	11	8	1	3	27.22
Unthinned	----	----	----	1	5	4	5	24	14	17	13	9	4	----	28.15
May 1:															
Thinned	----	----	----	1	7	9	20	27	42	22	9	0	1	----	27.39
Unthinned	----	----	----	----	1	1	5	13	25	22	12	6	2	----	28.48
May 14:															
Thinned	----	----	----	3	7	14	29	41	32	9	3	2	1	----	26.87
Unthinned	----	1	----	2	5	4	7	8	21	11	1	1	----	1	27.19
June 2:															
Thinned	----	----	----	6	32	24	29	7	8	1	1	----	----	----	25.29
Unthinned	----	----	----	----	----	8	16	14	4	1	----	----	----	----	26.39

The mean square periods for each flowering position on 27 plants taken in 1923 are arranged in Table 11 and show that the intervals are longer on the extremities of the plant. This increase was shown for Pima Egyptian cotton at Sacaton, Ariz., in 1921,[4] but was attributed to the squares on the extremities of the plant being produced later in the season. This is a logical conclusion to be drawn from a single planting, but with side-by-side comparisons of early and late plantings the seasonal effect apparently is not responsible for the lengthening of the intervals. Therefore it appears that a correlation exists between the square period and the position on the plant, or that the lengthening of the square period on the extremities of the plant is due to the lack of vegetative vigor or the slowing up of plant growth during such period.

TABLE 11.—*Mean interval from the appearance of squares until flowering dates for each node of each fruiting branch from records of 27 cotton plants in 1923*

Fruiting branch	Node and interval (days)				Fruiting branch	Node and interval (days)			
	Node 1	Node 2	Node 3	Node 4		Node 1	Node 2	Node 3	Node 4
No. 1	25.65	25.40	27.46	----	No. 8	26.59	28.07	28.25	----
No. 2	26.85	26.25	27.80	----	No. 9	25.94	28.66	----	----
No. 3	26.35	26.55	27.16	28.20	No. 10	26.72	----	----	----
No. 4	26.92	27.00	26.66	----	No. 11	27.90	----	----	----
No. 5	26.52	26.46	27.90	----	No. 12	28.20	----	----	----
No. 6	26.56	27.05	27.82	----	No. 13	29.40	----	----	----
No. 7	26.46	27.15	28.25	----					

MATURATION PERIOD OF BOLLS

In 1924 the maturation period of bolls was determined for the different dates of planting by tagging several hundred flowers in each planting on several dates from July 17 to August 6. An equal number of flowers were tagged on the thinned and unthinned rows. These tags, bearing the date of flowering, were collected and recorded

[4] MARTIN, R. D., BALLARD, W. W., and SIMPSON, D. M. GROWTH OF FRUITING PARTS IN COTTON PLANTS. Jour. Agr. Research 25: 195-208, illus. 1923.

for each day as the bolls opened. In this way it was possible to determine the differences in the maturation period of the bolls representing the different dates of planting and the different spacings from bolls that were set on the same date.

The records show that the maturation period of bolls was little affected by dates of planting and that the period lengthened with the advance of season on all plantings alike. Although the flowers produced on the same day in the different plantings did not have the same positions on the plants, the maturation period of the bolls remained practically the same for flowers of the same day. Bolls that were set August 6 in the April 10 planting were among the last bolls produced in that planting and were located on the outer extremities of the plants, whereas the bolls set August 6 in the June 2 planting were among the first bolls produced in that planting and were located on the first nodes of the lower fruiting branches.

The mean maturation periods for bolls set on the several dates in the different plantings and spacings are presented in Table 12.

TABLE 12.—*Mean maturation periods of bolls set on different dates in thinned and unthinned rows of cotton in plantings of 1924*

Date of planting	Mean maturation period (days)						
	Bolls set July 17	Bolls set July 22		Bolls set July 27		Bolls set Aug. 6	
		Thinned	Unthinned	Thinned	Unthinned	Thinned	Unthinned
April 10	38.53	39.71	41.30	41.25	41.26	50.16	50.41
May 1	38.65	39.37	41.25	42.28	42.77	50.20	51.00
May 14	38.79	41.66	41.23	42.20	42.00	51.41	51.33
June 2				39.08	41.60	48.13	51.41

The most outstanding difference in the periods of maturation of thinned and unthinned cotton occurred in the June 2 planting, where the mean maturation period for the bolls set July 27 was 39.08 days on plants spaced 12 inches apart and 41.60 days on the plants in the unthinned rows. For the bolls set August 6 the mean maturation period was 48.13 days in the 12-inch spacing and 51.41 days in the unthinned rows. Such pronounced differences did not occur in all dates of planting. The stand of the June 2 planting was exceptionally good, and the unthinned sections were somewhat more crowded.

TABLE 13.—*Frequency distribution of the maturation period of bolls that were set July 27 and August 6 on thinned and unthinned cotton planted on June 2, 1925*

Spacing	Interval from flowering to opening of boll (days) and frequency distribution																	
	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	Mean
Bolls set July 27:																		
Thinned	8	7	8	1														39.08
Unthinned			1	3	5	1												41.60
Bolls set Aug. 6:																		
Thinned									3	3	4	3	1				1	48.13
Unthinned											1	1	2	2	2	2		51.45

The maturation period of bolls in the June 2 planting in the thinned and unthinned sections is shown in Table 13. Whether the bolls grew more slowly in the unthinned rows or opened less promptly was not determined. During the maturation period of the bolls set August 6, 8 inches of precipitation was recorded from September 11 to 13, which ended the hot, dry period that had prevailed for several months. After this rain the nights were cooler and the day temperatures more moderate.

RATE OF MATURITY OF SUCCESSIVE PLANTINGS

In 1923 open-boll counts were made at different dates during the opening of the crop, which showed the rate of opening in the different plantings and the dates on which each planting matured the bulk of its crop. Practically all bolls were open at the time of the last count, which was made just before picking. These data are shown in Table 14.

The bolls in the first four plantings opened at practically the same time, although there was a difference of three weeks in the date of planting. The opening of the bolls in the last five plantings corresponded to the order in which they were planted. Differences as small as four days in time of planting, which occurred between the May 3 and May 7 plantings, were apparently reflected in the date of maturity of the first bolls. The lack of differences in the rate of maturity between the early plantings may be accounted for by the fact that the first squares appeared on these plantings at approximately the same time.

TABLE 14.—*Number of open bolls at given dates on row sections 150 feet long for cotton plantings in 1923*

Dates of boll counts	Dates of plantings and number of bolls								
	Apr. 2	Apr. 9	Apr. 16	Apr. 23	May 3	May 7	May 14	May 21	May 28
Aug. 9	21	26	10	10	0	0	0	0	0
Aug. 13	100	113	70	44	0	0	0	0	0
Aug. 16	201	239	180	155	9	2	0	0	0
Aug. 20	272	319	244	261	34	9	1	0	0
Aug. 23	274	373	281	278	54	24	4	0	0
Aug. 27	375	447	350	379	138	63	12	1	0
Sept. 4	463	535	436	431	274	169	66	27	1
Sept. 11	563	622	562	600	427	312	307	268	131
Sept. 19	566	643	567	623	452	367	392	398	266
Sept. 26	566	643	567	627	491	383	409	440	325

GROWTH AND DEVELOPMENT OF VARIETIES

Records of the growth and development of different varieties were taken in the same manner and during the same seasons as those taken on the date-of-planting experiments. Seven varieties were used in these comparisons, including Kasch, Mebane Latest Improved, Rowden, Truitt, Lone Star, Acala, and Kekchi.

The number of days from planting to appearance of the first square, first flower, and first open boll for each variety studied in 1923 and 1924 are shown in Table 15. Little differences occurred in the rate of development between the different varieties during the same

season, and the seasonal variations correspond to the results obtained in the date-of-planting experiments. The varieties were planted May 5 in 1923 and April 19 in 1924.

The intervals between the appearance of successive fruiting branches and successive squares on fruiting branches were practically the same on all varieties studied, the variation in some of the varieties between the two years being greater than the differences between varieties. These intervals coincide with those reported in Tables 7 and 8, which represent the Lone Star variety in different dates of planting.

Table 15.—*Interval from planting to the appearance of first square, first flower, and first open boll for seven varieties of cotton grown in 1923 and 1924*

[Data recorded on 3 plants of each variety in 1923 and 10 plants of each variety in 1924]

Variety	Year	Days from planting to appearance of—		
		First square	First flower	First open boll
Kasch	1923	33	59	94
	1924	45	69	104
Mebane Latest Improved	1923	35	61	96
	1924	42	67	107
Rowden	1923	36	61	100
	1924	42	68	111
Truitt	1923	39	64	95
	1924	43	68	107
Lone Star	1923	35	62	99
	1924	45	70	111
Acala	1923	[1]	[1]	[1]
	1924	42	70	105
Kekchi	1923	35	60	95
	1924	43	69	105

[1] Plants killed by cotton root rot.

No significant differences were found in the square period of the different varieties for either of the two years, the greatest variation in the mean square period being from 25.01 to 26.80 days.

The growth rate of bolls was practically the same on all varieties, and agrees very closely with data reported by Martin, Ballard, and Simpson in 1923.[5] The average daily increase in size varied in accordance with the size of the mature bolls. The bolls on all varieties reached their maximum size at approximately the same age, except those borne on secondary fruiting branches, which were consistently smaller and reached their maximum size several days earlier. The mean maximum length of bolls borne on the primary fruiting branches was 50.27 millimeters, as compared with 41.70 millimeters for those borne on secondary fruiting branches.

The maturation period of bolls was found to vary from 33 days for bolls set early in the season to about 55 days for late-season bolls, with no consistent differences between varieties.

[5] MARTIN, R. D., BALLARD, W. W., and SIMPSON, D. M. GROWTH OF FRUITING PARTS IN COTTON PLANTS. Jour. Agr. Research 25: 203. 1923.

Table 16 shows the maturation period of 4-lock and 5-lock bolls of five different varieties grown in 1925. These data were obtained by tagging several hundred flowers on each variety July 21 and August 5 and collecting the tags as the bolls opened, noting the number of locks of each boll. This table shows no significant differences in the maturation period of 4-lock and 5-lock bolls nor between the different varieties.

TABLE 16.—*Frequency distribution of the maturation period of 4-lock and 5-lock bolls in five varieties of cotton grown in 1925*

Variety	Date bolls set	Locks per boll	Interval from flowering to opening of boll (days) and frequency distribution													Mean period
			38	39	40	41	42	43	44	45	46	47	48	49	50	
Kasch	July 21	4	----	3	8	10	8	9	4	1	1	----	----	----	----	41.75
		5	1	2	7	13	9	10	2	2	2	1	----	----	----	41.92
	Aug. 5	4	----	----	----	----	----	3	5	4	1	1	----	----	----	44.43
		5	----	----	----	----	1	12	10	4	1	2	----	----	----	43.93
Mebane Latest Improved	July 21	4	----	3	1	7	9	7	7	12	8	6	5	----	----	44.01
		5	2	0	5	3	5	3	9	5	3	2	1	----	----	43.13
	Aug. 5	4	----	----	----	----	1	4	8	2	6	3	1	----	----	44.84
		5	----	----	----	----	1	5	2	4	5	3	1	----	----	44.95
Lone Star	July 21	4	----	----	----	2	2	1	6	11	5	7	4	3	----	45.51
		5	----	----	3	2	1	3	1	7	11	10	6	2	----	45.52
	Aug. 5	4	----	----	----	----	----	1	4	2	3	1	1	----	----	45.17
		5	----	----	----	----	----	5	2	8	7	3	1	----	----	45.15
Acala	July 21	4	----	1	3	2	7	6	2	2	2	----	----	----	----	42.52
		5	4	5	17	15	14	10	9	2	6	3	1	----	----	41.99
	Aug. 5	4	----	----	----	----	----	2	2	0	1	0	1	----	----	44.67
		5	----	----	----	----	1	9	4	2	1	1	2	----	----	44.20
Kekchi	July 21	4	3	0	4	0	2	3	6	5	4	4	2	8	7	45.54
		5	2	0	0	1	4	2	3	2	4	4	1	4	1	44.96
	Aug. 5	4	----	----	----	----	----	8	1	6	12	7	4	2	1	45.83
		5	----	----	----	----	----	3	6	3	7	3	3	2	----	45.66

The opening of the bolls set July 21 was extended over a long period and so distributed as to obscure partially the seasonal effect in the means, but the frequency distribution shows a striking contrast between the two dates in every case.

SUMMARY

The data here reported relate to the growth and behavior of the cotton plant, under various cultural methods, as affected by environmental conditions at Greenville, Tex.

Special attention has been given to the effect of different dates of planting and different spacings upon the normal rate and sequence of production and the growth and development of the fruiting parts.

Flowers appear in ascending series along the main axis of the plant about three times as fast as in a horizontal series along the fruiting branches. The mean interval between the appearance of flowers on the first nodes of successive fruiting branches was 2.40 days, as compared with 6.2 days between the appearance of successive flowers on the fruiting branches of the same plants.

In the date-of-planting experiments the germination and early growth of seedlings were more rapid in the late plantings. The time from planting to appearance of the first square ranged from 58 days on a planting made April 2 to 19 days for plantings made July 24 and August 15.

The interval between the appearance of successive fruiting branches was little affected by the date of planting. The means for 1923 ranged from 2.28 ±0.146 to 2.93 ±0.173 days. In 1924 there was a slight tendency for the intervals between the appearance of successive fruiting branches to be longer on the closer spacings.

The intervals between the appearance of successive squares on fruiting branches were very irregular, with no significant differences between the different dates of planting. In comparing the different spacings, the intervals between the appearance of successive squares on fruiting branches were longer in the unthinned rows than in the 12-inch spacing of each date of planting.

The rate of square production appears to be directly related to the vegetative vigor of the plants and not necessarily affected by the advance of the season. Long intervals between the appearance of squares may occur at any time during adverse weather conditions or when the plants are reaching maturity or bearing a heavy crop of bolls.

The square period, or the time from the appearance of a square until it flowers, showed a decided tendency to shorten on later plantings and was longer on the unthinned cotton than on the 12-inch spacing.

The lengthening of the square period on the outer nodes of the branches appears to be definitely related to the position on the plant or the slowing up of plant growth during the late season.

The maturation period of bolls was little affected by the date of planting, but lengthened with the advance of the season. This period was also somewhat longer in the unthinned rows than in the 12-inch spacing, especially where the unthinned stand was very thick.

The time from planting to maturity of the crop was much longer on the earlier plantings, but most of this time was spent in the seedling stage, before the appearance of the first square.

No significant differences were found in the rate of growth and development of fruiting parts between any of the varieties studied when planted on the same date and subjected to the same cultural treatment and weather conditions.

The maturation periods were recorded separately for 4-lock and 5-lock bolls on five varieties in 1925. These data show no relation between the number of locks per boll and the maturation period, the 4-lock and 5-lock bolls opening together in each variety.

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December 10, 1926

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